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LATE BAJOCIAN BIOEVENTS OF AMMONOID IMMIGRATION AND COLONIZATION IN THE AREQUIPA BASIN

(PUMANI RIVER AREA, AYACUCHO, SOUTHERN PERU)

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SUMMARY

Strata of the Socosani Formation in the Pucayacu and Pumani sections (Ayacucho Department, Peru), along several kilometres, have yielded Upper Bajocian ammonoid fossil-assemblages characterized by the occurrence of juvenile individuals belonging to endemic or pandemic taxa, such as *Megasphaeroceras* and *Spiroceras* respectively. In addition, certain Bajocian taxa relatively common in the Mediterranean-Caucasian Subrealm, but very scarce in the Eastern Pacific Subrealm, such as the strigoceratid *Cadomoceras* and the phylloceratid *Adabofoloceras*, occur in this area. These Late Bajocian bioevents of regional appearance of immigrant ammonoids and even sustained colonization should be associated with an episode of maximum deepening, maximum relative sea-level rise and highest oceanic accessibility of a Bajocian-Bathonian deepening/shallowing palaeoenvironmental cycle in the Arequipa Basin, during the Late Bajocian Niortense Biochron.

INTRODUCTION

Bajocian ammonoids are scarce in the Peruvian Andes, although there are well-developed marine deposits in the southern areas of Peru (Westermann et al. 1980; Riccardi et al. 1992; Alvan de la Cruz 2009; Carlotto et al. 2009; Giraldo Saldivar 2010). The Socosani Formation (Yura Group) corresponds to deep marine environments going from shelf deposits to slope turbidites with olistolith development, and reach thicknesses greater than 900 m in the southern areas of Totos and Paras (Ayacucho Department). A Bajocian stratigraphic succession of high biostratigraphic completeness, within the southern Peruvian areas belonging to the Arequipa Basin, crops out in the area of Pumani River, 300 km SE of Lima. It is located 17 km S of Totos, in the boundary between the provinces of Victor Fajardo (Vilcanchos and Sarhua districts) and Huanca Sancos (Lucanamarca District).

The primary aim of the present work is to focus on the composition and structure of the Bajocian ammonoid associations at the outcrops of Pumani River (Pucayacu and Pumani sections), calibrated in units of European standard chronozones, in order to interpret the successive palaeoenvironmental changes of the Arequipa Basin and their implications in sequence stratigraphy.

GEOLOGICAL SETTING

In the Pumani River area (Fig. 1), grey limestones with microfilaments (*Bositra* sp.) of the Socosani Fm represent Aalenian and Early Bajocian open marine platform and ridge to slope deposits. This Calcareous Member is the southward equivalent of the Chunumayo Fm, developed through a shallow platforms system as meridional margin of the Pucara Basin. Distinctively, slump deposits and redeposited sediments indicative of slopes occur within the Calcareous Mb in the Pumani Section, as well as microbial laminae and centimetric, domical structures in the uppermost levels, indicative of sedimentary starvation. Above, two lutaceous stratigraphic intervals well differentiated surpass 700 m in thickness. The Lower lutaceous Mb consists of brown and black shales with intercalations of limestones and calcareous sandstones, varying between 50 and 200 m in thickness. The Upper lutaceous Mb is composed of grey and green shales with intercalations of calcareous sandstones, where at least middle Upper Bajocian marine deposits surround isolated megablocks of lowermost Upper Bajocian marine deposits, reaching tens of metres in thickness. The uppermost decametric blocks, observable on a distance of several kilometres and interpreted as olistoliths, correspond to Late Bajocian and Bathonian deep-water slope and basinal deposits.

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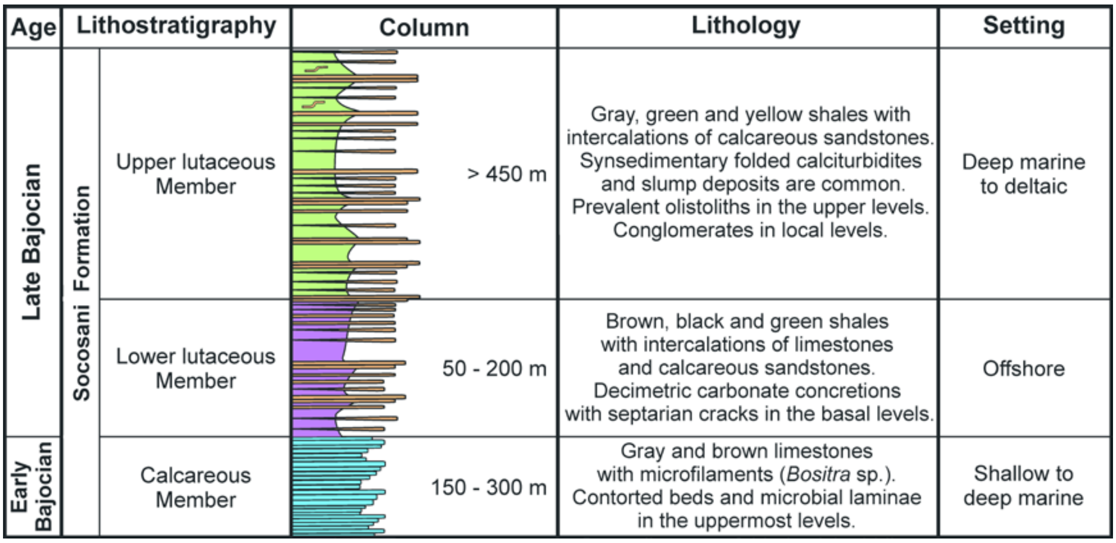

Figura 1. Age, lithostratigraphic unit, column, lithology and depositional setting of the Rio Pumani area.

PALAEONTOLOGICAL REMARKS AND PALAEOENVIRONMENTAL IMPLICATIONS IN SEQUENCE STRATIGRAPHY

Ammonoids are scarce in the Socosani Fm at the Pumani River area, particularly in the lower calcareous interval, although they are locally common in the lutaceous members. New field samplings and the revision of earlier collections provided several hundreds of Bajocian ammonoids from this area. The uppermost Aalenian Malarguensis Biozone and lowermost Bajocian levels can be identified by the occurrence of *Puchenquia (Gerthiceras)* cf. *mendozana* Westermann [Macroconch] and *Tmetoceras* cf. *flexicostatum* Westermann [M] in the lower part of the Calcareous Mb, according to the biostratigraphic data obtained in Argentina and Chile (Riccardi & Westermann 1991). Above, several specimens of *Pseudotoites* [M & m] and *Sonninia* [M] characterize the Laeviuscula Zone, whereas higher and sparse specimens of *Chondromileia* [M & m], *Sonninia* [M], *Pelekodites* [m], *Stephanoceras* [M] and *Skirroceras* [m] indicate the Sauzei Zone. At the upper levels of the Calcareous Mb, some fragmentary specimens of *Dorsetensia* sp. [M], associated with *Stephanoceras* [M], allow the recognition of the Lower Bajocian Humphriesianum Zone. In the Lower lutaceous Mb, successive ammonoid fossil assemblages characterize the Upper Bajocian Magnum Biozone introduced for the Neuquen-Mendoza Basin (Westermann & Riccardi 1979) as equivalent to the Rotundum Chronozone proposed in North America and to the Niortense Standard Chronozone. The taxa identified in this biostratigraphic interval indicate a time span from the latest Niortense Zone to the Garantiana Zone. The occurrence of *Megasphaeroceras* cf. *magnum* Riccardi & Westermann [M & m], *Spiroceras orbignyi* (Baugier & Sauze) and *Leptosphinctes* spp. [M & m] characterizes the uppermost Niortense Zone. The Garantiana Zone is recognized in the uppermost levels of the Lower lutaceous Mb and mainly in higher levels belonging to the Upper lutaceous Mb, with *Megasphaeroceras* cf. *magnum*, *Spiroceras orbignyi, S. annulatum* (Deshayes) and *Vermisphinctes* spp. [m & M]. Above, several fragmentary specimens may belong to *Planisphinctes* [m & M] and suggest the last Bajocian Parkinsoni Zone (as identified in the Tarapaca Basin, northern Chile, by Fernandez-Lopez & Chong Diaz 2011). The finding of only one *Iniskinites* also suggests the first Bathonian deposits including the uppermost olistoliths of the Upper lutaceous Mb.

Late Bajocian Eurycephalitinae are dominant and *Megasphaeroceras* [M & m] is the most common ammonoid genus (45%), with endemic species to the southeastern Pacific borderlands. They are recorded by shells of monospecific group, showing unimodal size-frequencies distribution of positive asymmetry, dominant juveniles and dimorphism well represented (taphonic populations of type 1, as indicated in Table 1). Also locally common are Leptosphinctinae (26%) and Spiroceratinae (15%). *Leptosphinctes* [M] - *Cleistosphinctes* [m] show juvenile and pre-adult individuals in the Lower lutaceous Mb, whereas *Vermisphinctes* [m] - *Prorsisphinctes* [M] are mainly represented by adults in the uppermost levels of this lower interval and within the Upper lutaceous Mb. *Spiroceras orbignyi* is represented by dominant juveniles in the Lower lutaceous Mb, whereas *Spiroceras annulatum* is very scarce and almost restricted to the Upper lutaceous Mb. Cadomitinae (6%), Lissoceratinae (4%), Phylloceratinae (2%), Oppeliinae (1) and Strigoceratinae (1%) are very scarce.

Most Bajocian ammonoid genera of the Pumani River area correspond to adult individuals belonging to taphonic populations of type 3 (TPT3, Table 1) dispersed by regional necrokinesis and/or local immigration, without evidence of sustained colonization, from more open marine or exotic oceanic areas. In contrast, Late Bajocian, monospecific populations dominated by juvenile individuals and indicative of sustained-colonization bioevents by eudemic taxa (i.e., recorded in their breeding area) were abundant among the genera Megasphaeroceras [M & m] and Spiroceras [M & m] (TPT1). These ammonite populations inhabiting the Arequipa Basin belong to endemic species to the Andean Province of the Eastern Pacific Subrealm and to pandemic species of the Tethys-Panthalassa Realm, respectively. If the shells had been produced by immigrant taxa (TPT2) after active biodispersal from more marine or exotic, oceanic areas (i.e., miodemic taxa), it would probably be dominated by pre-adults of monospecific dimorphic genera. This is the case of the locally common Leptosphinctes [M] - Cleistosphinctes [m], displaying intermediate size-distribution with sorting of pre-adult ontogenic stages. The exceptional occurrence of monospecific populations, including macroconchs and microconchs such as in Vermisphinctes [m] - Prorsisphinctes [M], even with predominance of microconchs, lacking juveniles but dominated by pre-adults, suggests autochthonous biogenic production of shells by miodemic taxa too, after immigration in the Arequipa Basin by active biodispersal. On the other hand, the occurrence of very scarce and monomorphic adult individuals of taxa relatively common and dimorphic in West Tethyan areas, such as the strigoceratid Cadomoceras or the phylloceratid Adabofoloceras, probably correspond to species recorded in a life area without breeding and occasionally reached by passive biodispersal (parademic species).

Therefore, the successive changes in composition and structure of the Bajocian ammonoid recorded associations of Pumani River outcrops, calibrated in standard chronozones, confirm that the regional changes of relative sea level drove, taphonomically and ecologically, the distribution of ammonoid shells in the Arequipa Basin. The Late Bajocian bioevents of regional appearance of immigrant ammonoids and even sustained colonization by *Megasphaeroceras* and *Spiroceras* should be associated with an episode of maximum deepening, maximum relative sea-level rise and highest oceanic accessibility of a Bajocian-Bathonian deepening/shallowing palaeoenvironmental cycle in the Arequipa Basin, during the Late Bajocian Niortense Biochron.

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Table 1. Ammonite taphonic populations in the Rio Pumani area

Class / Subclass / Order / Suborder / Superfamily / Family / Subfamily / Genus	East-Pacific Subrealm	Mediterran-Caucasian Subr.	Aalenian	Discites Zone (Bajocian)	Laeviuscula Zone (Bajocian)	Sauzei Zone (Bajocian)	Humphriesianum Zone (Bajocian)	Niortense Zone (Bajocian)	Garantiana Zone (Bajocian)	Parkinsoni Zone (Bajocian)	Bathonian
Cephalopoda Cuvier, 1798											
Ammonoidea Fischer 1882											
Phyllocerida Schindewolf, 1923											
Phyllocerina Zittel, 1884											
Phylloceratoidea Zittel, 1884											
Phylloceratidae Zittel, 1884											
Phylloceratinae Zittel, 1884											
Adabofoloceras Joly, 1977	x	x							2		
Calliphylloceratinae Spath, 1927											
Holcophylloceras Spath, 1927	x	x				3	3				
Ammonitida Fischer, 1882											
Ammonitina Fischer, 1882											
Hammatoceratoidea Schindewolf, 1964											
Graphoceratidae Buckman, 1905											
Tmetoceratinae Spath, 1936											
Tmetoceras Buckman, 1892 [M]	x	x	3								
Hammatoceratidae Buckman, 1867											
Hammatoceratinae Buckman, 1887											
Puchenquia Westermann & Riccardi, 1972	x		3	?							
Sonniniidae Buckman, 1892											
Sonninia Douvillé, 1879 [M]	x	x		?	3	3					
Pelekodites Buckman, 1923 [m]	x	x				3					
Dorsetensia Buckman, 1892 [M]	x	x					3				
Haploceratoidea Zittel, 1884											
Strigoceratidae Buckman, 1924											
Strigoceratinae Buckman, 1924											
Cadomoceras Munier-Chalmas, 1892 [m]	x	x							3		
Lissoceratidae Douvillé, 1885											
Lissoceratinae Douvillé, 1885											
Lissoceras Bayle, 1879 [M]	x	x						3	3	3	
Microlissoceras Sturani, 1971 [m]	x	x						3	3	3	
Oppeliidae Douvillé, 1890											
Oppeliinae Douvillé, 1890											
Oppelia Waagen, 1869 [M]	x	x						?			
Oecotraustes Waagen, 1869 [m]	x	x						3			
Stephanoceratoidea Neumayr, 1875											
Stephanoceratidae Neumayr, 1875											
Stephanoceratinae Neumayr, 1875											
Stephanoceras Waagen, 1869 [M]	x	x				3	3				
Skirroceras Mascke, 1907 [M]	x	x				3					
Cadomitinae Westermann, 1956											
Cadomites Munier-Chalmas, 1892 [M]	x	x						3	3	3	3
Polyplectites Mascke, 1907 [m]	x	x						3	3	3	3
Spiroceratinae Hyatt, 1900											
Spiroceras Quenstedt, 1858 [M & m]	x	x						1	2	3	
Otoitidae Mascke, 1907											
Pseudotoites Spath, 1939 [M & m]	x				3						
Chondromileia Westermann & Riccardi, 1972 [M & m]	x					3					
Sphaeroceratidae Buckman, 1920											
Eurycephalitinae Thierry, 1976											
Megasphaeroceras Imlay 1961 [M & m]	x	x						1	2	3	3
Iniskinites Imlay, 1975 [M]	x										3
Perisphinctoidea Steinmann, 1890											
Perisphinctidae Steinmann, 1890											
Leptosphinctinae Arkell, 1950											
Leptosphinctes Buckman, 1920 [M]	x	x						2			
Cleistosphinctes Arkell, 1953 [m]	x	x						2			
Vermisphinctes Buckman, 1920 [m]	x	x							2		
Prorsisphinctes Buckman, 1921 [M]	x	x							2		
Planisphinctes Buckman, 1922 [m]	x	x								?	
Lobosphinctes Buckman, 1923 [M]	x	x								?	
CHARACTERISTIC TYPE OF TAPHONIC POPULATION:			**3**	**?**	**3**	**3**	**3**	**1**	**2**	**3**	**3**
DEEPENING-SHALLOWING PALAEOENVIRONMENTAL CYCLE:											

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